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ABSTRACT

In March 2011, SAD detected 46 square kilometers of deforestation in the Legal Amazon. This represented a reduction of 39% in comparison to March 2010 when the deforestation totaled 76 square kilometers.

The accumulated deforestation during the period from August 2010 to March 2011, corresponding to the first eight months of the current deforestation calendar, totaled 972 square kilometers. There was a slight decrease of 3% in relation to the same previous period (August 2009 to March 2010) when the deforestation totaled 1,000 square kilometers.

In March 2011 the states with the largest deforestation area were Rondônia with 69%, followed by Mato Grosso 23%. The rest of the deforestation occurred in Acre (4%), Pará (2%) and Roraima (2%).

The degraded forests in Legal Amazon totaled 299 square kilometers in March 2011. Compared to March 2010, when the deforestation totaled 220 square kilometers, this means a 35% increase. The majority (73%) of this deforestation occurred in Mato Grosso followed, quite far, by Rondônia (27%).

The accumulated forest degradation during the period from August 2010 to March 2011 totaled 4,056 square kilometers. In relation to the previous period (August 2009 to March 2010) there was a significant increase (225%) when the forest degradation totaled 1,248 square kilometers.

In March 2011, the deforestation detected by SAD resulted in a commitment of 1 million tons of CO₂ equivalents which represents a reduction of 23% in relation to March 2010. With the accumulated on the period (August 2010 - March 2011) the deforestation resulted in a commitment of 60 million tons of CO₂ equivalents and represented a reduction of 8% in relation to the previous period (August 2009 to March 2010).

It was possible to monitor with SAD only 19% of the forest area in Legal Amazon in March 2011. The other 81% were covered by clouds making difficult to monitor the region, especially in Pará and Mato Grosso, where respectively 93% and 80% of the forest area was covered by clouds. These states had been responsible for major deforestation of the Amazon region.

Deforestation Statistics

According to the Deforestation Alert System (SAD) of Imazon, the deforestation (i.e., the forest total removal with soil exposure) in March 2011 in Legal Amazon reached 46 square kilometers (Figure 1 and

Figure 2). This represented a reduction of 39% in the deforestation of March 2011 in relation to the deforestation detected in March 2010, when the deforestation reached 76 square kilometers.

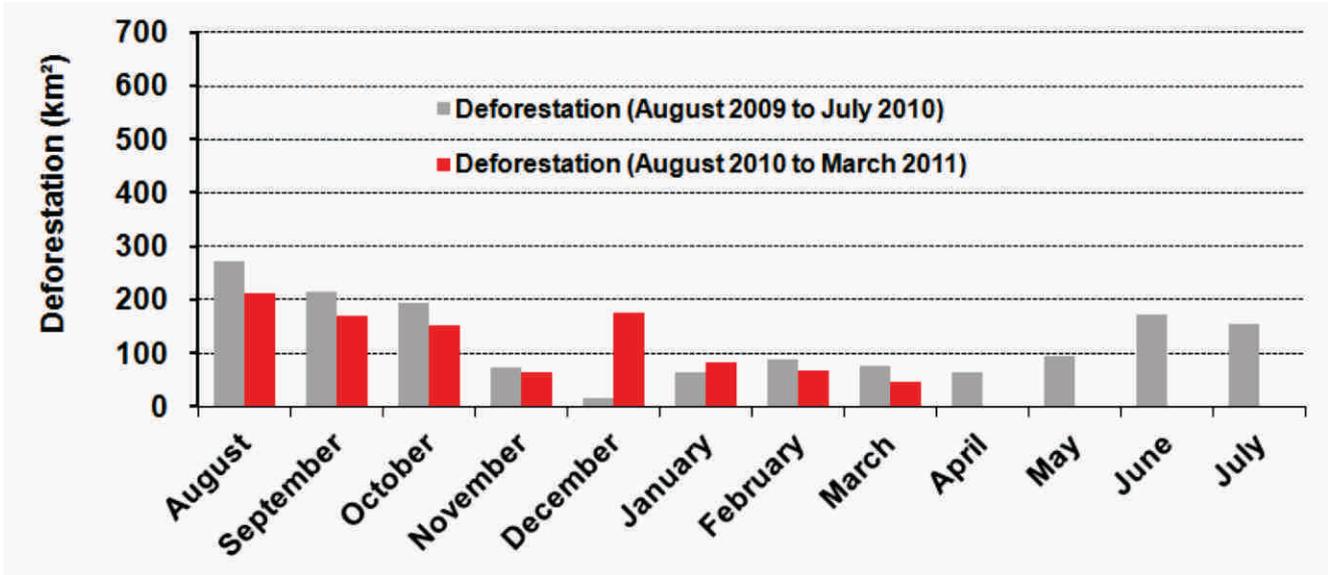


Figure 1. Deforestation from August 2009 to March 2011 in Legal Amazon (Source: Imazon/SAD).

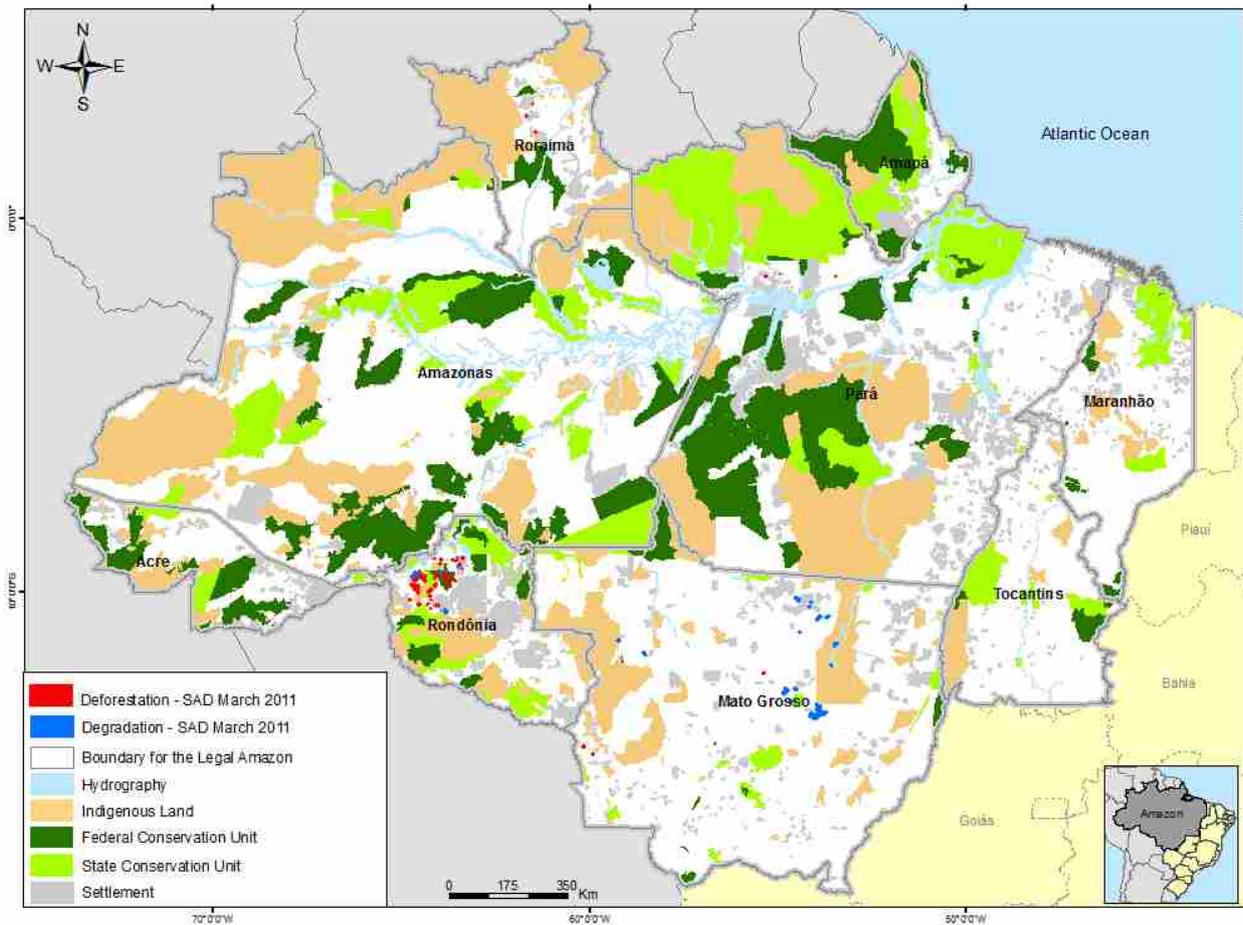


Figure 2. Deforestation and Forest Degradation in March 2011 in Legal Amazon (Source: Imazon/SAD).

The accumulated deforestation during the period from August 2010 to March 2011¹, corresponding to the first eight months of the current official deforestation measurement, reached 972 square kilometers. There was a reduction of 3% of the deforestation in relation to the previous period (August 2009 to March 2011) when it reached 1000 square kilometers.

In March 2011 the states with the largest deforestation area were Rondônia with 69%, followed

by Mato Grosso 23%. The rest of the deforestation occurred in Acre (4%), Pará (2%) and Roraima (2%). The deforestation in Pará was lower in March 2011 probably due to the fact that this state was covered a great quantity of clouds (93% of the forest area covered by clouds).

In March 2011, Rondônia was responsible for 69% of the total deforested area in Legal Amazon (Figure 3). Then, comes Mato Grosso with 23%, Acre with 4%, Pará with 1% and Roraima with 1%.

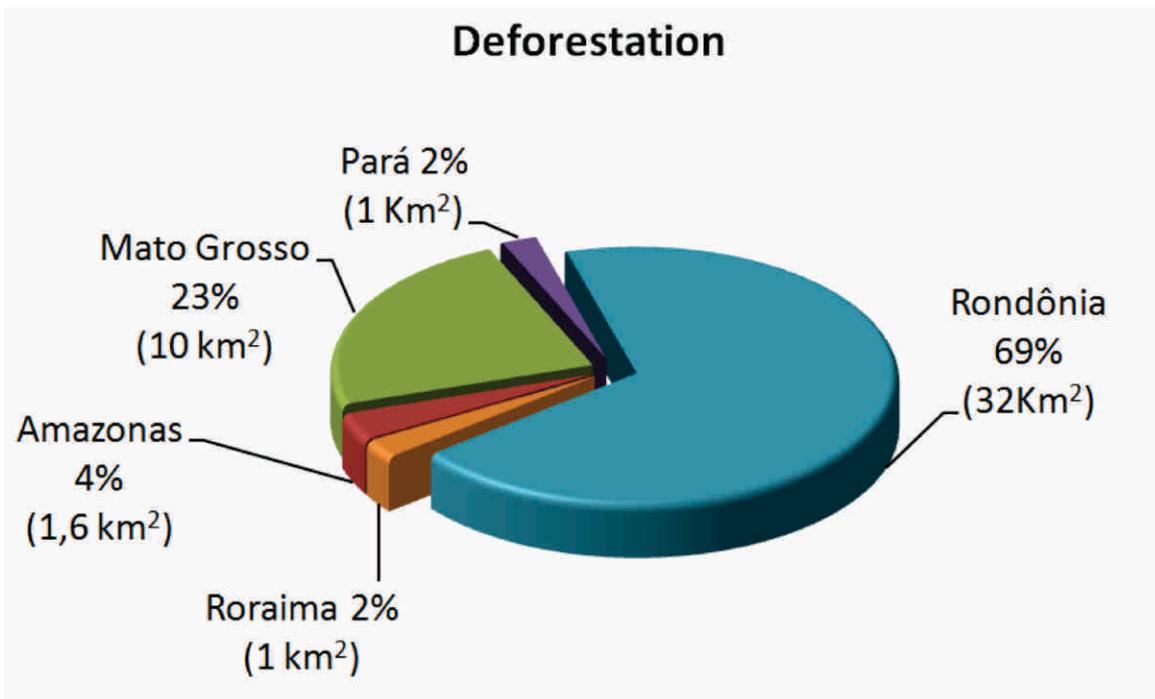


Figure 3. Deforestation (%) in the Legal Amazon states in March 2011 (Source: Imazon/SAD).

Considering the first eight months of the current deforestation calendar (August 2010 to March 2011), Mato Grosso leads the ranking with 28% of total deforestation in the period. Next comes Rondônia with 26%, Pará with 26% and Amazonas with 12%. These four states were responsible for 93% of the deforestation in Legal Amazon occurred in that period. The rest (7%) of the deforestation occurred in Acre and Roraima.

The deforestation that occurred from August 2010 to March 2011 was 3% lower than the

deforestation of the previous period (August 2009 to March 2010) (Table 1). In relative terms, there was a reduction of 84% in Roraima and 47% in Pará. Moreover, there was an increase of 671% in Tocantins, 300% in Tocantins, 142% in Rondônia, 54% in Acre, 31% in Amazonas and 22% in Mato Grosso.

In absolute terms, Mato Grosso leads the ranking of the accumulated deforestation with 263 square kilometers, closely followed by Rondônia (274 square kilometers), Pará (257 square kilometers), and Amazon (120 square kilometers).

¹ The official calendar for deforestation measurement begins in August and ends in July.

Table 1. Evolution of the deforestation among the Legal Amazon states, from August 2009 to March 2010 and from August 2010 to March 2011 (Source: Imazon/SAD).

State	August 2009 to March 2010	August 2010 to March 2011	Variation (%)
Acre	36	55	+ 53
Amazonas	91	120	+ 32
Mato Grosso	225	274	+ 22
Pará	476	254	- 47
Rondônia	106	257	+ 142
Roraima	50	8	- 84
Tocantins	1	4	+ 300
Amapá	15	-	-
Total	1,000	972	- 3

* The data of Maranhão were not analyzed..

Forest Degradation

In March 2011, SAD reported 299 square kilometers of degraded forests (forests intensely explored by wood and/or burning activities) (Figures 2 and 4). In relation to the same period of the previous year (in March 2010 there was an increase of 35%

when the forest degradation reached 220 square kilometers. From the total, the majority (73%) of this degradation occurred in Mato Grosso, followed by Rondônia (27%).

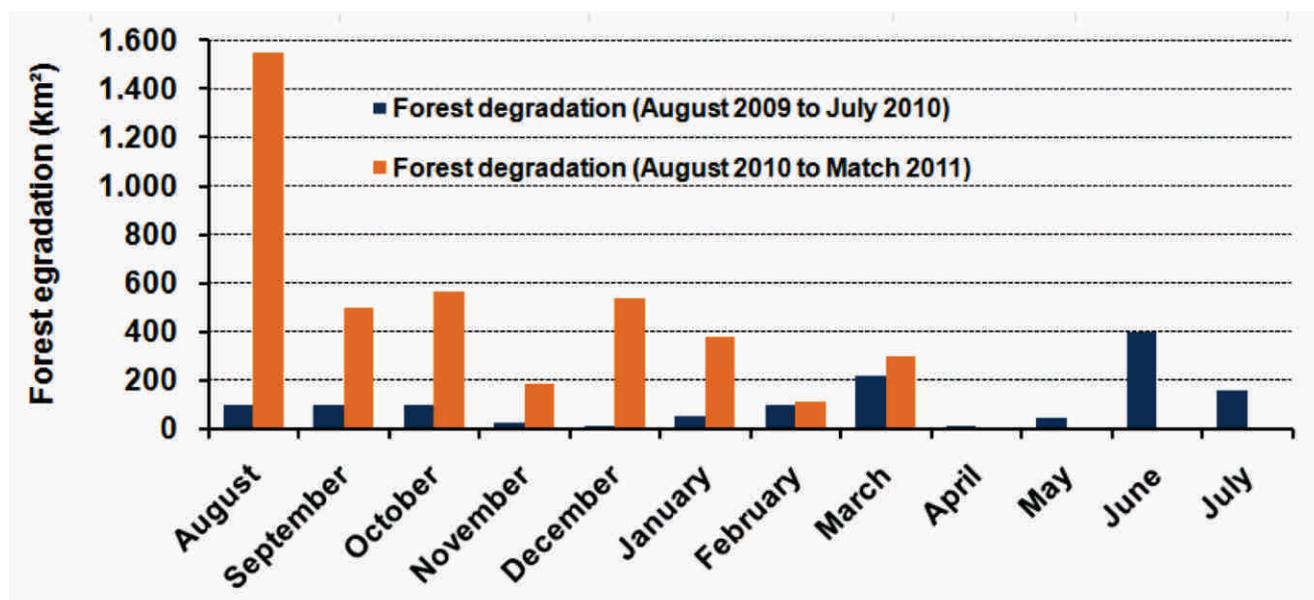


Figure 4. Forest degradation from August 2009 to March 2011 in Legal Amazon (Source: Imazon/SAD).

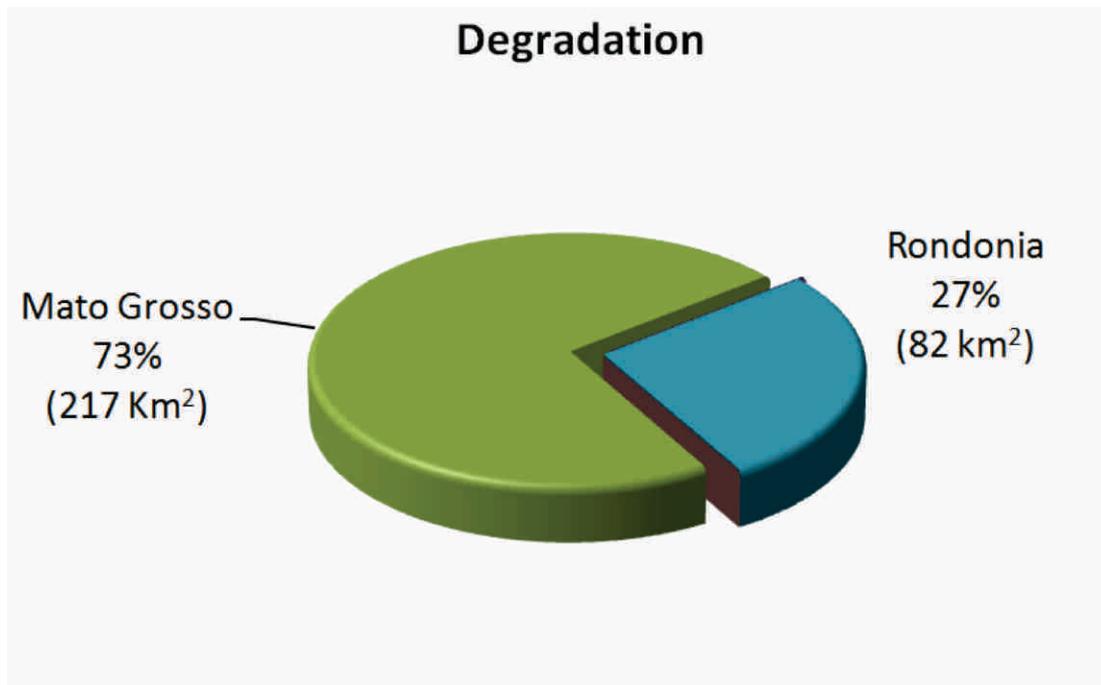


Figure 5. Forest Degradation (%) of the Legal Amazon states in March 2011 (Source: Imazon/SAD).

The accumulated forest degradation in the period from August 2010 to March 2011² (first eight months of the official calendar of the deforestation measurement) reached 4056 square kilometers. This represents an extremely significant increase of 225% in accumulated forest degradation during this period (August 2010 to March 2011) in relation to the same period of the previous year (August 2009 to March 2010) when the forest degradation totaled 1.248 square kilometers (Table 2).

In relative terms, Tocantins presented a significant increase of 2,600%, but in absolute terms the increase was reduced changing from just 1 square kilometer from August 2009 to February 2010 to 27 square kilometers from August 2010 to March 2011. Other states also contributed to increase the forest degradation: Amazonas (+576%), Acre (+ 504%),

Mato Grosso (+222), Pará (+214) and Rondônia (+183). Moreover, Roraima showed a reduction of 75% in forest degradation.

Mato Grosso leads the ranking with 55% of the accumulated degraded forest areas total in the period from August 2010 to March 2011. Next come with 23% Pará and Rondonia with 14%. These three states were responsible for 92% of the forest degradation in Legal Amazon during that period. The remaining 8% occurred in Amazonas, Acre, Roraima and Tocantins.

In absolute terms, Mato Grosso leads the ranking of the accumulated forest degradation with 2,224 square kilometers, followed by Para (941 square kilometers), Rondônia (575 square kilometers), Acre (145 square kilometers), Amazonas (142 square kilometers), (Tocantins 27 square kilometers) and Roraima (2 square kilometers).

² The official calendar for deforestation measurement begins in August and ends in July.

Table 2. Evolution of the forest degradation among the states of Legal Amazon, from August 2009 to March 2010 and August 2010 to March 2011 (Source: Imazon/SAD).

State	August 2009 to March 2010	August 2010 to March 2011	Variation (%)
Acre	24	145	+ 504
Amazonas	21	142	+ 576
Mato Grosso	690	2224	+ 222
Pará	300	941	+ 214
Rondônia	203	575	+ 183
Roraima	8	2	- 75
Tocantins	1	27	+ 2,600
Amapá	1	-	- 100
Total	1,248	4,056	+ 225

* The data of Maranhão were not analyzed.

Carbon Affected by Deforestation

In August 2011, the 46 square kilometers of deforestation detected by SAD in Legal Amazon affected 1 million tons of carbon (with an error margin of 196 thousand tons). This amount of affected carbon results in 3,8 million tons of CO₂ equivalent (Figure 6). This represents a drop of 23% in relation to March 2010 when the affected forest carbon was 1,3 million tons. This reduction in carbon affected by deforestation was lower than the reduction of 39% of the deforestation detected by SAD this month.

The forest carbon affected by the deforestation in the period from August 2010 to March 2011 (the first eight months of the current deforestation calendar) was 16.3 million tons (with a margin of error of 398 thousand tons), representing approximately 60 million tons of CO₂ equivalent (Figure 6). In relation to the same period of the previous year (August 2009 to March 2010) there was a reduction of 7.8% of the quantity of carbon affected by the deforestation.

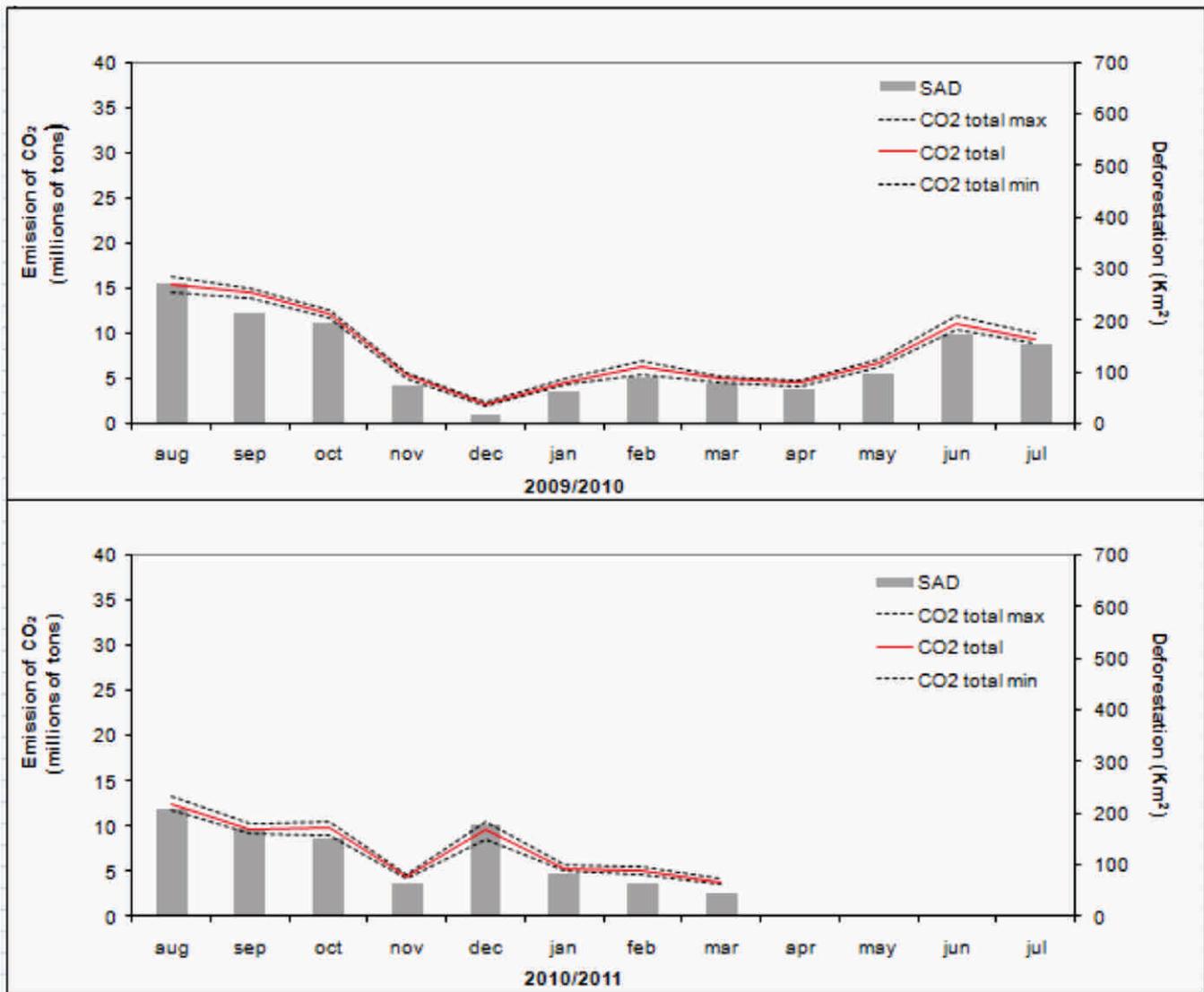


Figure 6. Deforestation and emissions of total Carbon Dioxide (CO₂) equivalent from August 2009 to August 2011 in Legal Amazon (Source: Imazon).

Geography of Deforestation

Regarding the land title status in March 2011, the majority (71%) of the deforestation occurred in private areas or in areas under different stages of ownership. The

remaining deforestation was recorded in Conservation Units (25%), and far after in Agrarian Reform Settlements (3%), and in Indigenous Lands (1%) (Table 3).

Table 3. Deforestation per land title category in March 2011 in the Legal Amazon (Source: Imazon/ SAD).

Category	March 2011	
	km ²	%
Agrarian Reform Settlement	1.3	3
Conservation Units	11.5	25
Indigenous Lands	0.3	1
Private, Owned & Vacant ³	33.0	71
Total (km²)	46	100

Agrarian Reform Settlements

SAD registered only 1.3 square kilometers in the Agrarian Reform Settlements during March 2011. The Settlements most affected by the deforestation

were Vale do Jamari (Candeias do Jamari, Rondônia), Rio Preto do Candeiais (Candeias do Jamari, RO), Nilson Campos (Porto Velho, RO) (Figure 7).

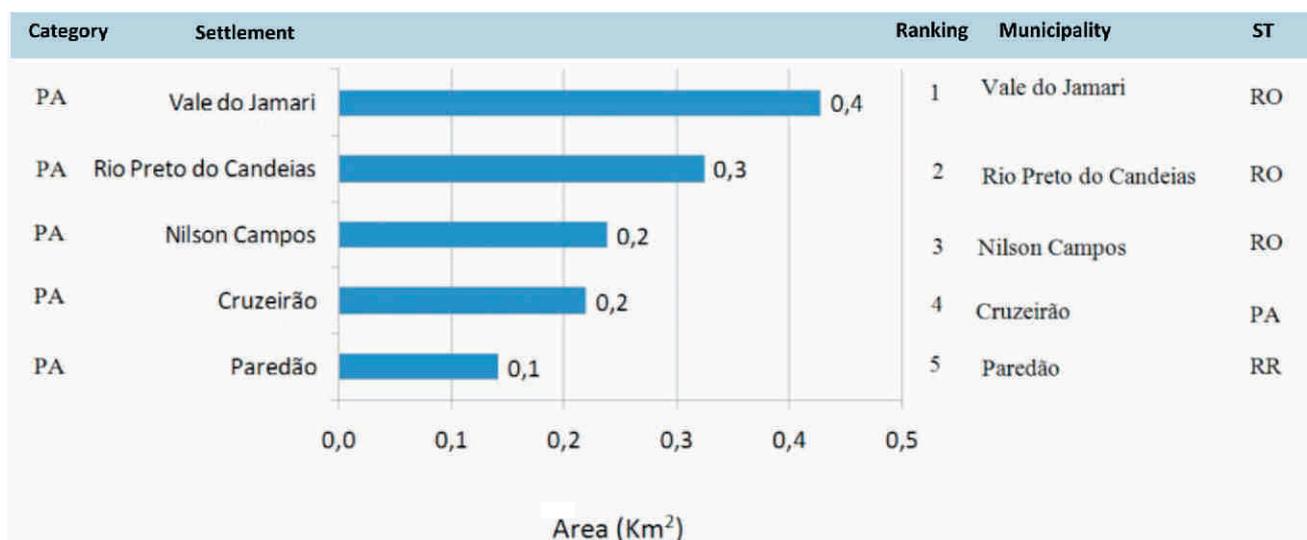


Figure 7. Most deforested Agrarian Reform Settlements in February 2011 in Legal Amazon (Source: Imazon/SAD)

³ Includes private areas (owned or not) and unprotected public forests.

Protected Areas

SAD detected 11.5 square kilometers of deforestation in conservation areas (Figure 8). The Conservation Areas affected by deforestation were in Rondonia: RESEX Jaci Paraná, APA Rio Pardo, and

Flona do Bom Futuro. In the case of Indigenous Lands, in March 2011, deforestation was only detected in the IT Karitiana in Rondônia (Figure 9).

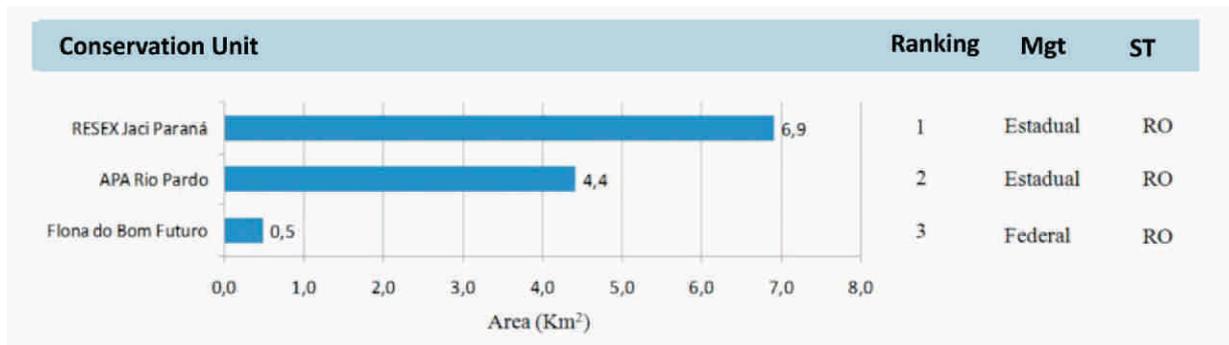


Figure 8. The most deforested Conservation Areas in Legal Amazon in March 2011 (Source: Imazon /SAD).

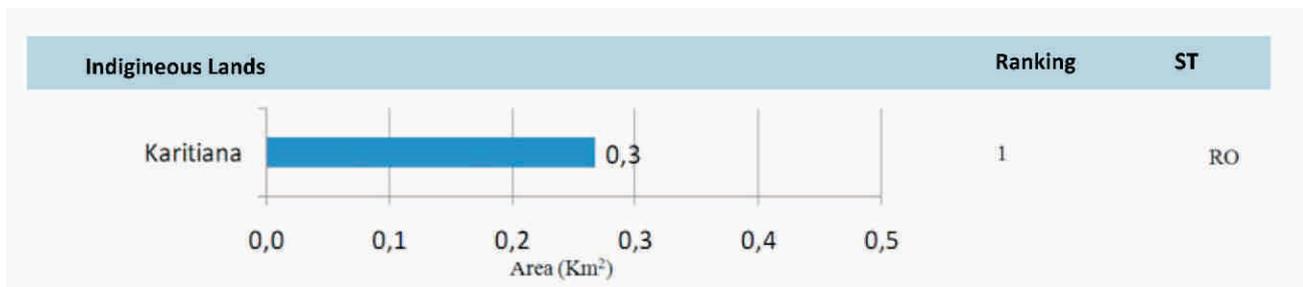


Figure 9. Most deforested Indigenous Lands in Legal Amazon in February 2011 (Source: Imazon /SAD).

Critical Municipalities

In March 2010, the municipalities most affected by deforestation were: Porto Velho

(Rondônia), Nova Lacerda (Mato Grosso) and Buritis (Rondônia) (Figure 10 and 11).

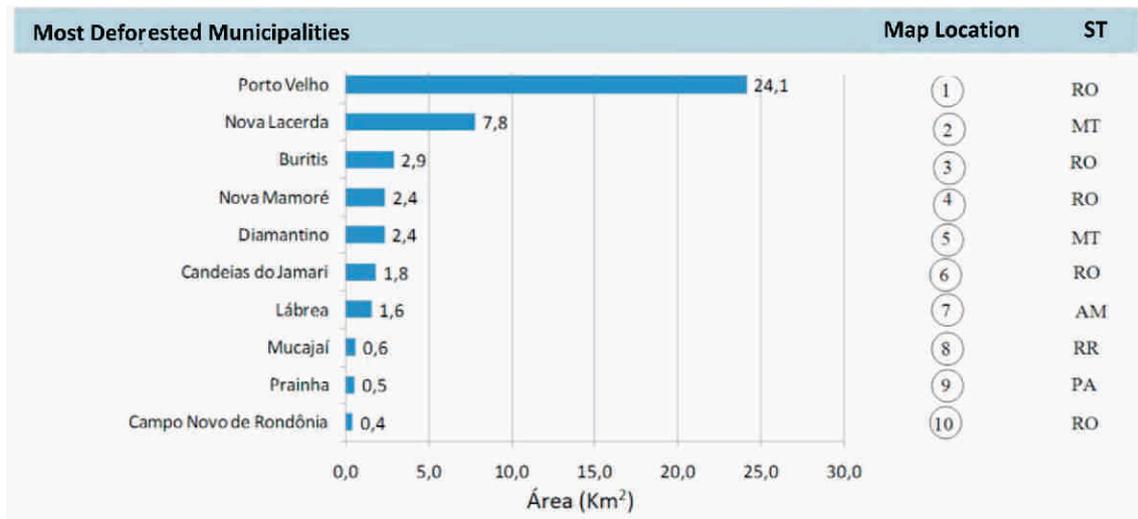


Figure 10. Most deforested Municipalities in Legal Amazon in March 2011 (Source: Imazon /SAD).

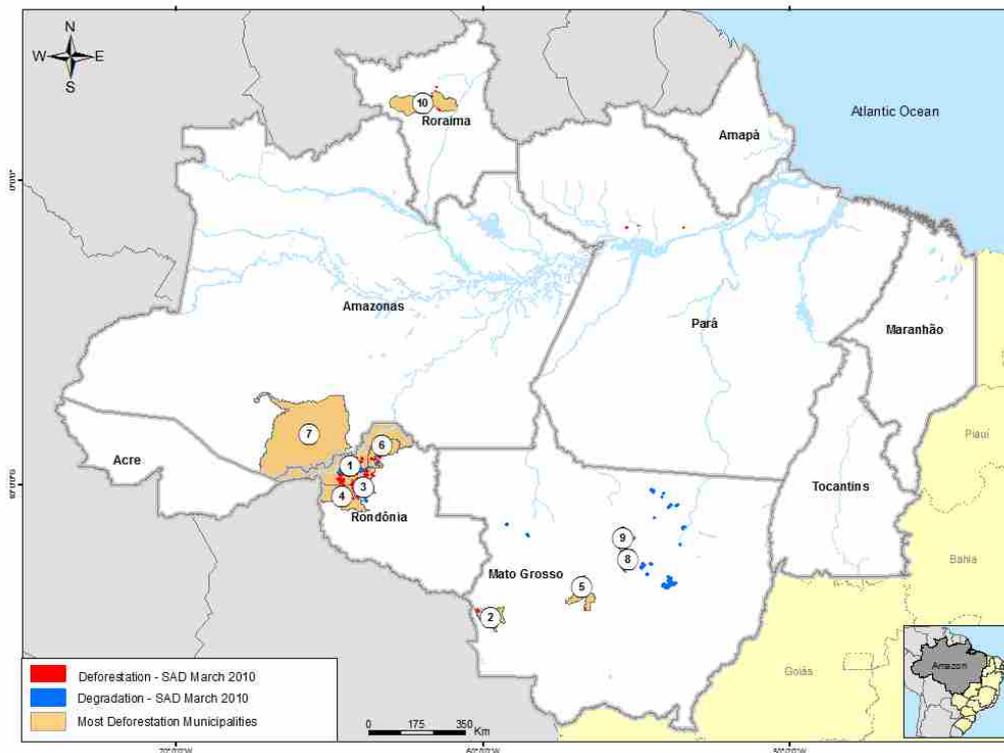


Figure 11. Most deforested Municipalities in March 2011 (Source: Imazon/SAD).

Cloud and Shade Cover

In March 2011, it was possible to monitor with SAD only 19% of the forest area in the Legal Amazon. The other 81% of the territory were covered by clouds making difficult to monitor, especially in Pará, Mato Grosso, Acre and Amapá (Figure 12). These states had more than 80% of the forest territory covered by

clouds. Because of that, the deforestation data for these States may be underestimated in March 2011. The period from December to March is characterized as a rainy season in the Amazon region, then it becomes difficult to monitor deforestation through satellite images.

* Part of Maranhão that integrates Legal Amazon was not analyzed.

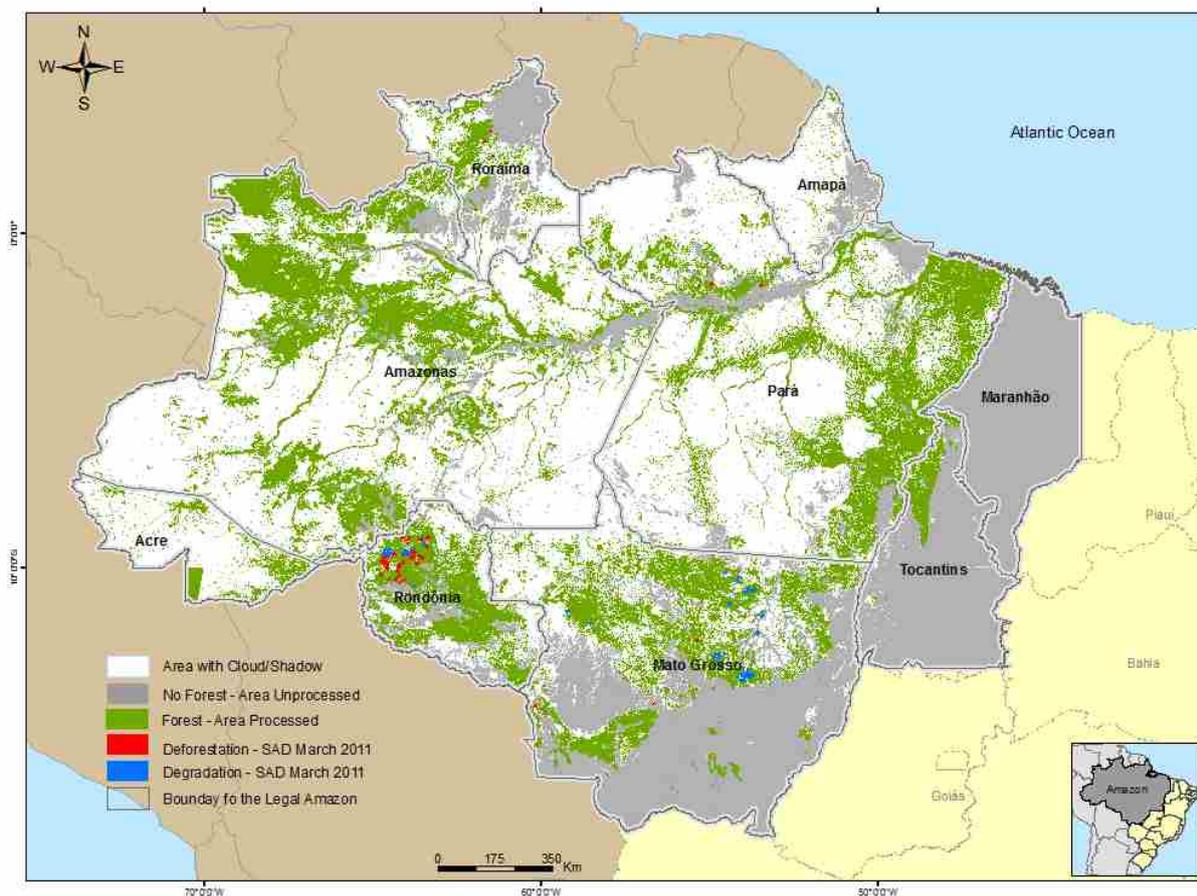


Figure 12. Area with cloud and shade in March 2011 in Legal Amazon.

Validation of the SAD data using Landsat and Cbers Imaging

The SAD data are validated through the use of CBERS and Landsat imaging (finer spatial resolution) available through the Instituto Nacional de Pesquisas Espaciais (Inpe). The images available soon after the month analyzed by SAD were used. All the deforestation polygons detected by SAD are checked using the detailed images. Deforestation less than 6.25 hectares, that is, below the detection capacity of SAD, are not included in the statistics, in case they occur in the images with more detailed resolution. However, if false signs of deforestation detected by SAD are confirmed, these are removed from the monthly statistics.

In March 2011, only 23% of the deforestation detected by SAD was confirmed with the Landsat images (Figure 13). The other 77% were not confirmed due to the huge quantity of clouds on the Landsat and CBERS images available at that time.



Figure 13. Landsat scenes used in the validation of the deforestation polygons detected by SAD in March 2011.

Section I: SAD 3.0

Since August 2009, SAD presented some innovations. First, a graphic interface was created to integrate all the image processing programs used in the SAD. Secondly, we began computing the deforestation in areas that were covered by clouds in the previous months under a new class. Lastly, the deforestation and degradation were detected with pairs of NDFI images in a change detection algorithm. The main methodology continues to be the same as SAD 2 as shown below.

SAD generates temporary MODIS images daily from the products MOD09GQ and MOD09GA for cloud filtration. A fusion technique for different spectral resolution bands, that is, with pixels of different sizes, was then used. In this case, the 5 bands scale with a pixel of 500 meters of the MODIS was changed to 250 meters. This allowed the improvement of the spectral pixel mixture model, providing the ability to estimate the abundance of Vegetation, Soils and Non-Photosynthetic components (NPV from the English – Non-Photosynthetic components (Vegetation, Soil and Shade) to calculate the NDFI with the equation below:

$$\text{NDFI} = \frac{(\text{VGs} - (\text{NPV} + \text{Solo}))}{(\text{VGs} + \text{NPV} + \text{Solo})}$$

Where VGs is the Vegetation component normalized for shade given by:

$$\text{VGs} = \text{Vegetation} / (1 - \text{Shade})$$

NDFI varies from -1 (pixel with 100% of exposed soil) to 1 (pixel with > 90% with forest vegetation). Therefore, we have a continuous image showing the transition of the deforested areas, passing through degraded forest until it reaches forests without signs of disturbance.

This month the detection of the deforestation and degradation had different NDFI images of consecutive months. Therefore, a reduction in the NDFI values between -200 and -50 indicated possibly deforested areas and between -49 and -20 with signs of degradation.

SAD 3.0 Beta is compatible with the previous versions (SAD 1.0 and 2.0) because the deforestation detection threshold was calibrated to generate the same type of response obtained by the previous method.

SAD is already operating in the state of Mato Grosso since August 2006 and in Legal Amazon since April 2008. This bulletin presents the monthly data generated by SAD from August 2006 to August 2010.

Section II: Carbon affected by the deforestation

Since January 2010, the affected carbon (that is, the forest carbon subject to emissions due to burning and decomposition of forest biomass waste) estimates from the deforestation detected by SAD in Legal Amazon was reported.

The carbon estimates are generated based on the combination of SAD deforestation maps with simulations of the spatial biomass distribution for the Amazon. A carbon emission estimation model, based on stochastic simulation (Morton in prep.) Called (CES). One thousand (1000) spatial biomass distribution simulations in the Amazon were generated using a geostatic model (Sales et al., 2007), and these biomass simulations were transformed into C-stocks using biomass conversion factors for C from literature, according to the formula below:

$$C_t = \sum C(S)_t$$
$$C_t(S) = S_D \times \left[(BVAS - BPF) \times (1 - fc) \times (t == 0) + (BAS_0 \times pd \times e^{(-pd \times t)}) \right]$$
$$BPF = ff * AGLB$$
$$BAS_0 = bf * AGLB$$

where:

t: time (month)

Ct: Carbon emitted in month t.

Ct(S): Carbon emitted from a deforested polygon at time t.

SD: Deforested area:

BVAS: Biomass aboveground at the deforested region SD.

BPF: Biomass from forest products removed from forests before the deforestation.

fc: coal fraction (3 to 6%).

BAS0: Underground biomass before deforestation.

pd: monthly decomposition parameter of the underground biomass after deforestation (0.0075). Monthly decomposition rate of underground biomass after deforestation.

To apply the CES model using the SAD data, only the carbon affected by the deforestation was considered, which is the fraction of forest biomass made up of carbon (50%) subject to instant emissions caused by forest fires from the deforestation and/or future decomposition of the remaining forest biomass. Also, the CES model was modified to estimate the forest carbon affected by the deforestation on a monthly scale. Lastly, the simulations enabled the estimation of the affected carbon uncertainty, represented by the standard deviation (+/-2 fold) the simulations of the carbon affected each month.

Apply the value 3.68 to convert the carbon values for CO equivalent.

References:

- D.C. Morton¹, M.H. Sales², C.M. Souza, Jr.², B. Griscom³. Baseline Carbon Emissions from Deforestation and Forest Degradation: A REDD case study in Mato Grosso, Brazil. In preparation.
- Sales, M.H. et al., 2007. Improving spatial distribution estimation of forest biomass with geostatistics: A case study for Rondônia, Brazil. *Ecological Modelling*, 205(1-2), 221-230.

Data Source:

The deforestation statistics are generated from the SAD data (Imazon);
INPE Data - Deforestation (PRODES)
<http://www.obt.inpe.br/prodes/>

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